[SQUEAKING] [RUSTLING] [CLICKING]

VIVIAN SONG: In this video, I will be going over Goodie Bag number eight, which is about reactions and reaction rates. What you'll need are pH strips, small measuring cups, stirrers, gloves, citric powder, cups, a scale, and seashells. No sea animals were harmed in the making of this Goodie bag.

The objectives are to understand how climate change has caused ocean acidification. Assess the order of the reaction from empirical data. Learn how temperature can affect the reaction rate. And measure the pH of a reaction using pH strips. Some conceptual questions to think about are, what is the reaction order? And how does the reaction rate change if the temperature increases or if we have outside pH effects?

Now, in this Goodie bag, we will be exploring the application of reaction rates in ocean acidification due to climate change and what that means for many sea animals. As you can see from this graph, there is a strong positive correlation between increasing carbon dioxide levels in the atmosphere, which is marked by the red, and decreasing pH in the ocean, which corresponds to increasing acidity, as seen in the green.

What exactly is going on in terms of the chemistry? First, carbon dioxide from the air dissolves into the oceans and reacts with water to form carbonic acid. Then the carbonic acid donates a proton. Finally, calcium carbonate from seashells reacts with excess protons in solution to formed bicarbonate ions. What does this all mean? Seashells are dissolving in a more acidic ocean, which is very sad.

One final note about the slide. I've only drawn the forward reaction arrows. But these reactions are actually reversible. So there should also be backward arrows. However, the forward reactions are more dominant to the reverse reactions. So the net product is that of the forward reaction.

Now, let's dive into the experiment and see this happen in real life. First, take out one of your seashells and weigh it with your scale. Next, put on your elegant nitrile gloves. And take a large plastic cup and have it filled with tap water about halfway.

Measure out two scoops of the citric powder using the small but accurate measuring cup. And put it into the water. Then stir while using the stirrer until all of the citric powder is fully dissolved. It might take a minute of stirring, but the water should look pretty clear.

After that, you can use your pH strip to measure the pH of the solution. Have a timer ready. And when you're ready, place the shells that you weighed into the low pH solution. And record what you observe.

After 20 minutes, take out the shells with your gloves on and record the exact time. Let the shells dry for maybe half an hour or so so that all the water has evaporated. And then measure the weight. Repeat this step two more times so that you have data points of the mass of the shell at zero, 20, and 40 minutes. The pH that I measured was a pH of 2, as you can see using this pH tester.

While doing the experiment, you should see that the sea shells are dissolving in the acidic solution. And here, I've captured a hyper-lapse of this happening. The focus of our experiment is to figure out the reaction rate of the dissolution of calcium carbonate. As a reminder, the reaction rate is equal to some rate constant times the concentration of the calcium ions to the n power times the concentration of carbonate ions to the n power, where n plus n is equal to the reaction order. And that is determined empirically from the data that we've gathered.

As you can see from the data, this reaction is 0th order. I plotted the concentration of carbonate ions on the y-axis, which you can figure out, assuming that you poured 0.2 liters of water in your experiment, and time on the x-axis. Because this plot looks linear, the rate is constant over time and does not depend on the concentration of carbonate ions already in solution. Thus, this is a 0th order reaction. You could also imagine the same plot with calcium ions since we know that the calcium ions and carbonate ions exist in a one-to-one molarity ratio.

In summary, the reaction rate order is determined empirically. And the reaction rate can depend on temperature and pH. Now, we didn't have time to do this pH and temperature dependence experiment in the video. But you can imagine how temperature and pH might affect your reaction rate. And finally, ocean acidification linked to climate change is causing our seashells to dissolve, which is very sad.